How To Read A Scientific Paper

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Reading research papers takes practice!

- Scientific papers are full of terminology and ideas specific to a field of study – this can be intimidating
- Practice your reading skills often: the more papers you read carefully, the more informed and discerning you will become
- It takes experience and time to become an expert in your field and understand scientific papers.

Two main types of scientific papers

- Reviews
- Primary Research Papers

Scientific Review papers

- Present a summary of published data relating to a specific topic or research area
- Provide a general overview of the current state of the field as well as current paradigms
- Great resource for:
  - General knowledge about the topic
  - Historical context of the subject or field (references)
  - Helps the novice reader identify major players

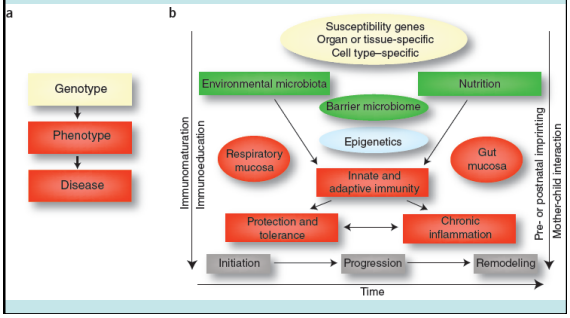
What to look for in a Review paper

- Published by an expert in the field
  - Have the author(s) published on the subject before?
- Journal status
- Written in plain language
- Good diagram/schematic may best convey main ideas
- Example: Renz et.al. "Gene-environment interactions in chronic inflammatory disease" *Nature Immunology* 2011

OR

-Geremia et.al. "IL-23-responsive innate lymphoid cells are increased in inflammatory bowel disease"
J Exp Medicine 2011

Renz et.al. "Gene-environment interactions in chronic inflammatory disease" *Nature Immunology* 2011



Primary Research Papers

- An author or group of authors is publishing novel data for the first time
- The data presented add new knowledge to the field and have the potential to advance the field

General format for a Primary Research Paper

- Abstract
- Introduction
- Materials and Methods
- Figures (data) and Results
- Discussion
- References
- Supplemental material

Five steps to getting the most out of a scientific paper

1. What are the main findings of the authors? (identify the hypothesis, conclusions and why the findings are important)
2. Be aware of authors and affiliations
3. Read the sections of the paper
4. Critically evaluate whether the data support the conclusions
5. Apply the data to your own research

Where is the hypothesis stated in a scientific paper?

- *If, then* statements usually do not appear in scientific papers
- hypotheses are tentative statements that propose a possible explanation to some phenomenon or event
- Usually found in the Abstract and Introduction
- The authors will propose to *test the hypothesis*

Hypothesis Example

- *If, Then* statement: *If* skin cancer is related to ultraviolet light exposure, *then* high exposure to UV light will cause skin cancer.
- In a scientific paper it may appear as:
  - Our preliminary data suggests that exposure to ultraviolet light will cause skin cancer
  - We propose that ultraviolet light causes skin cancer
  - Our data will show that skin cancer is caused by ultraviolet light

Find the main conclusions of the paper

- Often summarized in the Abstract and again at the end of the Introduction
- Hint: Most of the conclusions can be found in the Figure Legend titles, or in the headings of the Results section
- Example: Geremia et. al. Figure 1: "Th17 signature genes are expressed in intestinal CD3(-) cells and overexpressed in IBD"

Identify why the findings are important

- What aspect of the data or findings broadens our knowledge or moves the field forward?
- Hint: Often found in the Abstract and Discussion
- Example (Geremia et.al.): "*This study [examines]…the functional role of distinct ILC populations in intestinal inflammation and identifies a potential tissue-specific target for the treatment of patients with IBD*"

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Read the Geremia, et.al. paper (*J Experimental Medicine*) 2011

- Background information sheet provided in handouts
- When reading this paper, please identify:
  - The main question being asked
  - Hypothesis
  - Important pieces of data
  - Conclusions

Five Steps to Getting the Most Out of a Scientific Paper

1. How did it feel to read the paper?
2. What was the hypothesis?
3. What are the data?
4. What are the conclusions?

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Questions for evaluating the data

- Is the hypothesis testable? Can the authors find a method to link patient disease with gut cell phenotypes?
- Do the authors use a reasonable approach to test the hypothesis?
- Is the data presented in Geremia et. al."sound" and does it support the authors' conclusions?
- Are there other interpretations of the data?

How Do You Know If the Data Are Reasonable?

- Examine the figures and tables and look for data that meets these criteria:
  - Properly labeled
  - Correct axes
  - Proper controls
  - Where required: mean +/- SD; statistical analysis
  - At least two independent experiments performed

Example data from Figure 1

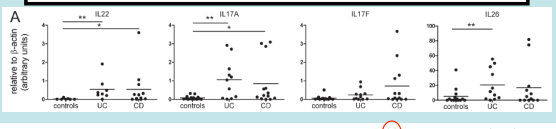

Figure 1. Th17 signature genes are expressed in intestinal CD3⁻ cells and overexpressed in IBD. (A) Relative messenger RNA (mRNA) expression of Th17 signature cytokines in intestinal tissue homogenates from control, UC, and CD patients. (B and C) mRNA expression of Th17-related genes in CD3⁺ cells (B) and CD3⁻ cells (C) isolated from blood and intestine of control (open circles) and IBD (closed circles) patients. In some experiments, B cells have been excluded (CD3⁻CD19⁻ cells). (A–C) The horizontal bars represent the mean of each of the groups. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

- Can you easily interpret the graphs ?
- Note the use of control samples
- Note the use of statistics to show significance between *control* and *experimental* samples
- Do you see any deficiencies?

Example data from Figure 2A

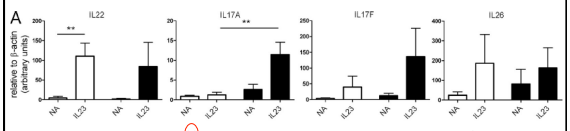

Figure 2. ILCs are a source of IL-17 in IBD. (A) mRNA expression of *IL22*, *IL17A*, *IL17F*, and *IL26* in CD3⁻ cells from control (open bars; $n = 9$ for *IL22*, *IL17A*, and *IL17F* and $n = 7$ for *IL26*) and IBD colon (closed bars; $n = 4$) after overnight culture in complete media with no addition (NA) and in the presence of 10 ng/ml IL-23. In some experiments, B cells have been excluded (CD3⁻CD19⁻ cells). **, $P = 0.006$. (B) mRNA expression of *IL22*, *IL26*, *IL17A*, and

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What information can be applied to your own project?

- Examine the Materials & Methods section for new techniques
- Reagents you could request for your own project? (flow cytometry antibody or patient samples)
- You may also identify potential collaborators

Consider how the data may advance the field

- New techniques
- New information on a biological pathway or new biomarkers
- Findings may modify existing paradigms
- Create debate, which creates interest

Think about how to apply the data to another scientific field

- Biological research is highly interdisciplinary
- Novel ideas and projects are often discovered by applying a new discovery to other fields or systems
- Challenge yourself to find a way to apply an idea or technology to your own project, especially if it is outside your field

Figure out the next step in the research

- When reading a paper, think about what experiments *you* would perform next if this was your project
  - This mental exercise may generate new ideas for your research!

Final Thoughts

- Learn to use the sections of the paper as a guide
- Most of your effort should be in examining the data (figures) and Results
- It is OK to disagree with the authors' conclusions or to consider that their interpretation was not supported by the data
- Remember: practice makes perfect!

Acknowledgements:

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Andrea McCollum, Ph.D.
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Final